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Physical science workshop course for elementary teachers

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Physical science workshop course for elementary teachers

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INTRODUCTION

Science for elementary school grades K–6 varies somewhat in content from one textbook series to another, but it is fairly common that 40–60% of the material covered is directly related to physics. These texts suggest that certain learning activities such as experiments, demonstrations, and observations be carried out by the teacher and the class. Often the apparatus for a learning activity is to be constructed from simple, readily available materials. The typical elementary school teacher has had little experience in performing experiments and is often frustrated in his/her attempts at carrying out the suggested learning activity. To meet this need we have developed a physical science workshop that is made available to teachers who are returning to the university for additional training.

This course is based upon the assumptions that most elementary teachers have had little or no physics and lack the competence and confidence to carry out an activity-oriented science program; that most experiments should be carried out using readily available and easily constructed materials; that skill in using hand tools is needed by most teachers; and that teachers who learn in an activity-oriented course are better prepared to teach in that mode.

FORMAT

The class is conducted in an informal workshop format in which each student works on her (since most participants are females, we choose to use the feminine gender) own apparatus and does the experiments individually. The lab-partner arrangement is not used since that tends to produce one "doer" and one "watcher." The course requires a total of 60 hours of participation, and participants may recieve up to four semester hours of credit toward a master's degree in education. The energy output of the instructor is very high, and the number of students per instructor should be limited to about twelve; although, we have successfully team taught sections as large as fifty by using four instructors. The instructor conducts demonstration experiments, pre-lab and post-lab explanations, and is otherwise constantly involved in explaining concepts to individual participants. The experiments can be divided into three types: (1) directed experiments, brief in duration, during which the instructor explains the results observed and helps the students understand what is observed (much of Unit I is of this type); (2) experiments carried out by the students and discussed in a post-lab session (Units II, V, and VI contain the best examples of these experiments); and (3) observation of phenomena utilizing easily contructed or readily available materials where data are not taken but the phenomenon is observed and described (Sec. III is the purest example of this type). Some of the sections mix all three approaches.

The course has been taught in several different time arrangements including one evening per week for an entire semester, two evenings per week for eight weeks during a regular semester, as a six-week summer course and as a three-week summer course. Each arrangement has some advantages and disadvantages. The first two have the advantages that the participant can put the material to immediate use in her classroom and have the instant reward of seeing the children's responses. One disadvantage is that both the participants and the instructor are tired after having worked all day, and this fatigue tends to limit enthusiasm. A second disadvantage is that all materials must be brought in and removed from the classroom for each class meeting.

The two summer programs lose the above advantages but more than make up for them by eliminating the disadvantages listed. Our experience indicates that the three-week course meeting 4–6 hours per day for ten to fifteen days in a room used for nothing else offers the best teaching situation.

The course has been taught in school cafeterias, libraries, elementary school classrooms, high school science laboratories, and university laboratories. We think it is best taught in an elementary school classroom since the participants overcome the same space and facility difficulties during the course as they will face in implementing a physical science program in their classes. Most importantly the course must be taught in a free and easy workshop atmosphere where students can learn from each other, get immediate answers to their questions and learn that doing science experiments can be an enjoyable experience.

Hand tools, lightweight electric drills, and saber saws are provided along with most materials needed to construct each piece of experimental apparatus. Each student builds apparatus with which she does experiments, and when the course is finished, she takes the apparatus she has built. Other experiments make use of commonly available materials, such as spectacle lenses, aquarium, and musical toys. When the course is finished each participant has enough materials to carry out nearly all of the experiments and demonstrations. Special apparatuses, which are either expensive or difficult to obtain, are avoided.

Every aspect of the program is part of a planned effort to give the participant confidence and competence to carry out an activity-oriented physical science program in her school.

CONTENT

It was our goal for each participant to gain a measure of competence in performing approximately 100 experiments and demonstrations from the various areas of physics. For example, in Unit I the student makes an alcohol burner from a baby food jar and clothesline rope and fuels it with spirit duplicator alcohol. The participants use the burner as the heat source for eleven experiments and demonstrations that can be done with test tube stoppers, glass tubing, and rubber hose. These experiments include boiling at low pressure, distillation of wood, distillation of liquids, and recrystallization of salt. Nine additional heat experiments are done in a later unit.

In the second unit an equal-arm balance sensitive to about 20 mg is constructed, and it is then used to carry out thirteen experiments including determination of the density of solids, liquids, and gases and a study of Archimedes's principle.

The optics unit contains 22 demonstrations and experiments using such items as mirror stock, pinhole cameras, aquarium, lenses, and shaving mirrors. Eleven experiments are included on weather, 16 on mechanics, 11 on sound, and 10 on electricity. A complete listing of the table of contents from our study guide is available on request from the author.

CONCLUSIONS

More than 200 persons have taken this course during the past six years, and student evaluations have been taken from approximately 100 of these. The course has been constantly rated as one of the best in which they have participated with respect to amount learned, potential for impact on teaching, and personal satisfaction with accomplishments. Follow-up interviews with teachers, science supervisors, and principals as well as unsolicited correspondence indicate that many who have taken the course have incorporated much of it into their science teaching.

Our experience indicates that physics departments can have an impact on public elementary school science teaching by developing and teaching courses that train the participant to conduct class experiments, develop apparatus, and perform the demonstrations that we have traditionally used in teaching elementary physics. However, the experiments need to be simplified and worked out so they can be done with readily available and easily constructed materials.

TABLE OF CONTENTS

13. Thumper—a hearing experiment
14. You can hear through your teeth
15. Church bells from a spoon

VIII. Electricity and magnetism
1. Magnetic field and iron filings
2. Use of compass to find magnetic field
3. Magnets—how to get them
4. Electromagnet
5. Current indicating device
6. Construction of a battery
7. Magnetize a needle
8. Generator effect
9. Experiments on practical electricity
10. Calculation of your electric bill

Kinematics of tape recording

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Recently,[1] J. P. McKelvey has given a quantitative description of the kinematics of audio tape recording. His description provides the nonlinear relationship between the numerical value on a counter attached to the tape take-up reel and the constant-speed, elapsed time of the tape. The discussion of Ref. 1 is of interest as a practical application of the mathematics of rotational kinematics. The purpose of this paper is to describe a slightly different approach, containing an important engineering assumption, to a similar problem involving microcomputer data storage on magnetic tape.

Cassette tape recorders are commonly used as an input–output (I/O) device for commercially available, low-cost microcomputers such as the Commodore PET. These recorders provide an inexpensive way to record programs and data files but are quite slow and seldom have a counter of the type described in Ref. 1. Programs recorded on the cassettes are normally several minutes in length with the result that, starting from the beginning of the tape, it may take tens of minutes to find and load the fourth or fifth program on the tape. An ideal solution to this problem is to make use of one of the higher-speed functions on the cassette recorder (fast-forward or rewind) to locate the program or data file and revert to normal speed for the actual I/O operation.

Perhaps the simplest way to optimize cassette tape usage is to divide the entire tape into equal segments or files of normal-speed recording time and then use the fast-forward speed to access the desired file from somewhere near the front of the tape. The PET computer has some built-in functions that are useful for this purpose. These include a memory location that holds the status of the cassette keys (senses if any key is depressed), a memory location that turns the cassette drive motor on and off, and a user-accessible, real-time clock that can be used as a timer. With suitable software then, the computer itself can be used to advance the tape at fast-forward speed for a precisely measured period of time, and locate the tape at the beginning of the desired tape file.

As mentioned in Ref. 1 the tape at normal speed passes the recording head at a constant velocity (for standard cassette recorders this velocity is 1.875 in./sec). In the fast-forward mode, however, the take-up reel rotates at a constant angular velocity, which means that the tape passes the recording head faster as the take-up reel fills. It becomes necessary to derive the nonlinear relationship between the time at normal speed and the time at fast-forward speed to advance from the start of the tape (or a suitable reference) to a specified point later on the tape.

The constant angular velocity ω, of the take-up reel must be determined experimentally. The change in radius Δr, of the take-up reel for each revolution is just the tape thickness h, which is 0.0005 in for a standard cassette tape. The time Δt, for each revolution is given by $1/\omega$. This implies that

$$\frac{\Delta r}{\Delta t} = \frac{dr}{dt} = h\omega, \qquad (1)$$

and indicates that for the fast-forward speed the radius $r(t)$, of the take-up reel is linear with time. Shown in Fig. 1 is experimentally obtained data for $r(t)$ of an ordinary cassette tape in a Commodore data cassette recorder. These data were obtained with a stopwatch, a ruler and a magnifying glass. The data are linear of the form $r(t) = r_0 + \alpha t$ where $r_0 = 0.41$ in. and $\alpha = 0.004\,25$ in./sec. From Eq. (1) the angular velocity is seen to be 8.5 sec.$^{-1}$.

At any time t, there have occurred n revolutions of the take-up reel in fast-forward where n is given by

$$n = [r(t) - r_0]/h. \qquad (2)$$

The length of tape L, on the take-up reel at this time is approximately[2]

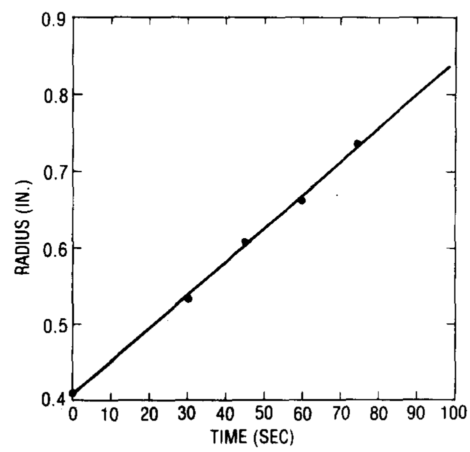

Fig. 1. Radius of a cassette recorder take-up reel as a function of time in the fast-forward mode of operation. The angular velocity of the reel is constant resulting in a radius that is linear with time.

